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ROYAL AIRCRAFT ESTABLISHMENT

F A R N B O R O U G H, H A N T S

TECHNICAL NOTE No: MECH. ENG. 79

847354

COMPARISON OF BLAST DAMAGE EFFECTS OF H.E./I AND H.E. CHARGES:

NOTE ON TRIALS, AT GROUND LEVEL, WITH 2 oz. FILLINGS DETONATED STATICALLY IN AIRCRAFT WINGS

by

G. SIMM, A.M.I.Mech.E., A.F.R.Ae.S.

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1. Ref ltr, PA, 24 Feb 59, ORDBB-TH8-461 (R4373), subj: Request for Report.

2. Inclosed is OTIA ID 847354 (S). This is a Royal Aircraft Establishment Technical Note No: Mech. Eng. 79, entitled "Comparison of Blast Damage Effects of H.E./1 and H.E. Charges: Note on Trials, at Ground Level, with 2 oz. Fillings Detonated Statically in Aircraft Wings," by G. Simm. This document may be retained.

1 Incl
OTIA ID 847354 (S)

Robert G. Blaylock
ROBERT G. BLAYLOCK
Lt Col, Ord Corps
Commanding

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R-2398-51
Comparison of Blast Damage Effects of H.E./1 and H.E. Charges
OARMA-London
June 1951 28 September 1951
1 JOHN L. ATKINS, Research Analyst RAE

Transmitted herewith is Royal Aircraft Establishment Technical Note No. Mech. Eng. 79 by G.W.Simm. It was required to establish whether the substitution of an H.E./I. filling in place of an H. E. filling for small D.A. fuzed shell would give an enhanced blast effect against aircraft structures. This Note describes a series of static detonation trials against Spitfire wing targets to check the relative blast damage effect with various H.E./I. and H.E. filling compositions. From the results of the trials it appears that H.E./I. fillings will give appreciably greater blast effect than plain H.E. fillings in small D.A. fuzed shell, under ground-level conditions. This superiority may be influenced to some extent by the scarcity of oxygen at high altitudes, and trials have been arranged to check this effect. The trials showed also that there is little difference in blast effect between a number of H. E./I. fillings. In order to determine the best type of H.E./I. filling it may be necessary to make comparative incendiary trials.

COMMENT: This report will be of interest to ORDTQ and ORDTB. The U.S.Naval and Air Attaches, London, receive copies of the inclosure.

1 Incl - As above (5 cys)

APPROVED, FOR THE ARMY ATTACHE:

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U.D.C. No. 623.451 : 623.565.33 : 629.13

Addendum to

3 Technical Note No. Mech. Eng. 79

6 August, 1951

Gt. Brit.

ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH 2

Further trials to compare the blast damage effect of experimental H.E. shell fillings detonated statically in aircraft wings

by

5 G. Simm

R.A.E. Ref: ME.7/9045/GS/63

In R.A.E. Technical Note No. Mech. Eng. 79 a series of trials was reported in which a number of experimental H.E./I. and H.E. fillings of 2 oz weight, in metal canisters, were detonated in Spitfire wings to check the variation in blast damage effect with changes in the filling composition. In these trials, the only H.E. filling included was R.D.X./T.N.T. (55/45). Two canisters remained from these trials and it was decided to fill these with C.E. and to detonate them in the same type of target (i.e. Spitfire wing leading edge, 7 ft outboard of wing root, at mid-depth and 3 in. forward of main spar).

As a result of the previous trials a suggestion was put forward that the method of initiation of the fillings would affect the damage effects. Lead azide/PETN was used to initiate the poured fillings and lead azide/C.E. was used to initiate the pressed fillings, and it was thought that the lead azide/PETN detonator might produce a higher degree of detonation and thus give greater blast damage effects. In order to check this contention, the two available canisters were both press-filled with C.E., and both fitted with an F.85 igniter, but one was fitted with a lead azide/PETN detonator and the other with a lead azide/C.E. detonator.

The trials with these two canisters were made at the Proof and Experimental Establishment, Shoeburyness, on the 3rd July, 1951.

The details of damage are given in the following table:-

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/Table I

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TABLE I

RD NO	Filling	Detonator	Details of Damage	Figure of Merit
19	2 oz C.E. - pressed	Lead azide/ C.E.	$3\frac{1}{2}$ ft span leading edge blown out. 4 ft span outboard ballooned and dished. 7 in. x 4 in. hole in spar web.	90
20	2 oz C.E. - pressed	Lead azide/ PETN	3 ft span leading edge blown out. 2 ft span outboard ballooned and dished and nose joint opened, and further 2 ft ballooned.	100

Thus, irrespective of the means of initiation, the C.E. Filling appears to give a damage effect of the same order as the H.E./I. fillings (i.e. Types A, C, G, H, J and K in the previous trials). This conflicts with the evidence of an earlier series of trials (Ref.1), when 20 mm shell, containing 0.4 oz of filling were detonated statically in Beaufighter wings. (In these trials the C.E. filling was markedly inferior to two types of H.E./I. filling). It is possible, therefore, that increasing the weight of the filling may tend to eliminate any difference between the damage effects of different filling compositions. Another possible explanation for the similarity of damage may be the size of the enclosed structure. Fig.3 of Ref.1 indicates a tendency for the damage effects to approach parity as the depth of the wing becomes less. Thus the relatively shallow depth of the Spitfire wing for the weight of filling used may have influenced the result.

Regarding the effect of the means of initiation, the canister initiated by lead azide/PETN (Rd. No.20) inflicted slightly greater damage than did the one initiated by lead azide/C.E. (Rd. No.19) (Figure of merit 100 compared to 90). The variation in detonator composition could, of course, account for this difference but, considering that greater differences were recorded previously between two identical fillings with the same detonator composition, it is considered that no great significance should be attached to these two results.

Since it is believed that lead azide/PETN will give a greater degree of reliability in detonation of fillings than lead azide/C.E., and at least equal effectiveness in causing blast damage to aircraft structures, the use of the lead azide/PETN detonator would appear preferable.

REFERENCES

No.	Author	Title, etc.
1	T. L. Hughes	Trials to determine the blast damage to aircraft wings from 20 mm shell with fillings of (a) Laminated H.E./I. (b) H.E. and (c) H.E./I. R.A.E. Tech. Note No. Mech. Eng. 70. April, 1951. (Reproduced in O.B.Proc. No. Q6894 (Special), 8th May, 1951).

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Technical Note No. Mech Eng. 79

June, 1951

ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH

Note on trials to compare the blast damage effects, at ground level, of various H.E./I and H.E. fillings, of 2 oz weight, detonated statically in aircraft wings

by

G. Simm, A.M.I. Mech E., A.F.R.Ae.S.

R.A.E. Ref: ME7/9045/GS/41

SUMMARY

It was required to establish whether the substitution of an H.E./I. filling in place of an H.E. filling for small D.A. fuzed shell would give an enhanced blast effect against aircraft structures. This Note describes a series of static detonation trials against Spitfire wing targets to check the relative blast damage effect with various H.E./I. and H.E. filling compositions.

From the results of the trials it appears that H.E./I. fillings will give appreciably greater blast effect than plain H.E. fillings in small D.A. fuzed shell, under ground-level conditions. This superiority may be influenced to some extent by the scarcity of oxygen at high altitudes, and trials have been arranged to check this effect. The trials showed also that there is little difference in blast effect between a number of H.E./I. fillings.

In order to determine the best type of H.E./I. filling it may be necessary to make comparative incendiary trials.

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

1 Introduction

A series of trials to determine whether a laminated H.E./I. shell filling gave a higher blast effect than conventional H.E. or H.E./I. fillings was made at the Proof and Experimental Establishment, Shoeburyness in March, 1951 (Ref.1). These trials showed that the degree of superiority of the laminated H.E./I. filling over the conventional H.E./I. filling was slight, but that both these types of filling gave an enhanced blast effect compared with a plain H.E. filling. Oerlikon shell with a filling weight of approximately 0.4 oz were used for the comparison.

As an extension of this investigation, it was required to establish whether, in larger D.A. fuzed shell which are normally filled H.E., the substitution of an H.E./I. filling would give enhanced blast effect, particularly with regard to fillings for 30 mm and 40 mm calibre shell.

Arrangements were made, therefore, by the Ordnance Board, for trials with canisters containing just over 2 oz of filling, to compare the blast effect of a number of experimental fillings against aircraft targets.

These trials were made at the Proof and Experimental Establishment, Shoeburyness on the 21st May, 1951. This Note records the conditions and results of the trials.

2 Description of ammunition

The ammunition supplied for the trials comprised steel cylindrical canisters, each with an internal diameter of 1.00 inch, an internal length of 2.75 inches and a wall thickness of 0.20 inch, fitted with a screwed plug at each end. The fillings for the canisters were described as follows:-

A. Laminated C.E./E.D.1.

B. Laminated C.E./E.D.1. with common salt in the lower 1/5 of the cavity.

C. C.E./S.R.379.

D. C.E./S.R.379, with common salt in the lower 1/5 of the cavity.

E. Torpex (poured), R.D.X./T.N.T./Al. (40/45/15).

F. R.D.X./T.N.T. (55/45).

G. C.E./Al. (90/10)/S.R.379.

H. R.D.X./Amm. Nitrate/T.N.T./Al. (30/10/45/15).

J. C.E./Al. (90/10)/E.D.1.

K. Torpex (pressed), R.D.X./T.N.T./Al. (40/45/15).

Canisters of types E. F. and H. were fitted with 2 gm. booster pellets of P.E.T.N. to ensure detonation of these fillings, which were poured. The canisters were filled by C.S.A.R., and full details of each filling, as supplied by C.S.A.R., are given in Table I.

Fillings B and D were included in the trials to check what reduction in blast effect would result if it were found possible to fill only 80% of the available capacity of a shell by the pressing method.

3 Trials procedure

For the purpose of the trials an igniter, electric, F.85 and a 6gr. ZY detonator were fitted in a hole in the top screwed plug of each canister, and each round was detonated statically in the leading edge of a Spitfire wing. The position of detonation within the wing was chosen to represent an attack from 20° below ahead, and was 7 ft. outboard of the root end of the wing. Each round was placed at mid-depth of the leading edge, approximately 3 inches forward of the main spar.

One specimen of each type of filling was checked first, and the extent of damage recorded. Check firings were then made with eight of the fillings (types B and J being omitted).

4 Results of trials

The detailed results of the trials are given in Table II, and Table III summarises the results in order of merit. Some illustrations of the damage effects are given in Figures 1 and 2.

5 Discussion of results

In order to differentiate more closely between the damage effects caused by the various fillings, a figure of merit has been assessed for each of the rounds fired. These values relate to the extent of damage inflicted, and are to the same standard as that adopted in previous trials against Spitfire wings (Ref.2).

Using these figures of merit as a criterion of the blast effect of the fillings against aircraft targets, it appears that the poured Torpex (Type E) filling is slightly superior to any of the others. The remaining six full-capacity H.E./I. fillings (Types A, C, G, H, J and K) all produced very similar damage effects and, since results from only two rounds of each are available, it would be unwise to consider any one of these types as superior to another.

In the earlier trials against Beaufighter wings (Ref.1), plain C.E. was used to represent the filling of an H.E. shell. In the present series of trials, the only H.E. shell filling used was type F (R.D.X./T.N.T.), and, as in the earlier trials, the H.E. type proved to be inferior to any of the H.E./I. fillings.

With an effective filling of only 80% of the available cavity (Types B and D) the blast effect was considerably reduced, the assessed effectiveness being of the order of 60% of that of the full charge.

6 Conclusions

For explosive shell of up to about 40 mm calibre, the addition of an incendiary mixture (or element) in the high explosive filling will apparently enhance the blast effect, and thereby increase the damage effect on aircraft structures, under ground level conditions.

Of the seven types of H.E./.I. filling included in the investigation, the poured Torpex (Type E) shows a slight but definite advantage over the broadly similar performance of the other six. All seven H.E./I. fillings gave significantly greater blast damage effects than the plain H.E. (R.D.X./T.N.T.).

The effect of partially filling the available cavity appears to reduce the damage effects to a greater extent than would be expected from the proportional reduction in filling weight.

7 Further developments

Ordnance Board trials are being arranged to check whether, of the fillings under review (all of which are oxygen deficient and are thus expected to give a degraded performance in rarified air), any one type will show marked superiority in blast damage effect under high altitude conditions.

Before final recommendations - based on the results of the investigation - are made, it would appear necessary to check that the main requirement (maximum blast effect) is not being obtained at the expense of a serious reduction in incendiary effect.

REFERENCES

No.	Author	Title, etc.
1	T. L. Hughes	Trials to determine the blast damage to aircraft wings from 20 mm shell with fillings of (a) Laminated H.E./I (b) H.E. and (c) H.E./I. R.A.E. Tech Note No. Mech Eng. 70 April, 1951. (Reproduced in O. B. Proc. No. Q6894 (Special), 8th May, 1951.)
2	-	Further lethality trials of small contact-fuzed shell. R.A.E. Note, Ref. ME7/9032/GS/72, dated 1st September, 1950.

Attached:

Tables I to III
Figs. 1 and 2
Neg Nos. 93782 - 93783.

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Technical Note No. Mech Eng. 79

TABLE I

DETAILS OF COMPOSITION OF FILLINGS

Filling	Method of Filling	Pellet Thickness mm.	Filling Composition	Total Wt. of Filling gm.
A	Pressed (Laminated)	10 12.5 12.5 10 12.5 12.5	9.0 gm. E.D.1. 10.5 gm. C.E. 10.5 gm. C.E. 9.0 gm. E.D.1. 10.5 gm. C.E. 10.5 gm. C.E.	60
B	Pressed (Laminated)	14 8 10 10 8 10 10	13.5 gm. common salt 7.0 gm. E.D.1. 8.5 gm. C.E. 8.5 gm. C.E. 7.0 gm. E.D.1. 8.5 gm. C.E. 8.5 gm. C.E.	48 (excluding salt)
C	Pressed	12 12 23 23	12.0 gm. S.R. 379 12.0 gm. S.R. 379 19.0 gm. C.E. 19.0 gm. C.E.	62
D	Pressed	14 9½ 9½ 18½ 18½	13.5 gm. common salt 9.5 gm. S.R. 379 9.5 gm. S.R. 379 15.5 gm. C.E. 15.5 gm. C.E.	50 (excluding salt)
E	Poured	-	59 gm. RDX/TNT/Al. (40/45/15) with booster pellet 2 gm. PETN/Wax (90/10).	61
F	Poured	-	56 gm. RDX/TNT(55/45) with booster pellet 2 gm. PETN/Wax(90/10)	58
G	Pressed	12 12 23 23	12 gm. S.R. 379 12 gm. S.R. 379 19 gm. C.E./Al(90/10) 19 gm. C.E./Al(90/10)	62
H	Poured	-	58 gm.RDX/Amm.nitrate/TNT/Al.(30/10/45/15) with booster pellet 2 gm. PETN/Wax(90/10)	60
J	Pressed	12 12 23 23	11 gm. E.D.1. 11 gm. E.D.1. 19 gm. C.E./Al.(90/10) 19 gm. C.E./Al.(90/10)	60
K	Pressed	14 14	11.5 gm.RDX/TNT/Al. (40/45/15) 11.5 gm.RDX/TNT/Al. (40/45/15)	

TABLE I (Contd.)

Filling	Method of Filling	Pellet Thickness mm.	Filling Composition	Total Wt. of Filling gm.
K contd.	Pressed	14 14 14	11.5 gm. RDX/TNT/Al. (40/45/15) 11.5 gm. RDX/TNT/Al. (40/45/15) 11.5 gm. RDX/TNT/Al. (40/45/15)	57.5

Notes

(a) All pellets were pressed 4 tons dead load.

(b) S.R.379 comprises 50% Mg. Al. alloy
47% Ba $(NO_3)_2$
3% Paraffin wax.

(c) E.D.1 comprises 30% Al.
30% Mg.
40% $KClO_4$.

/Table II

Technical Note No. Mech Eng. 79

TABLE II

DAMAGE EFFECTS AGAINST SPITFIRE WINGS OF EXPERIMENTAL SHELL FILLING

POSITION OF DETONATION:- 7 ft. inboard of root end of wing, at mid-depth of leading edge and 3 inches forward of main spar.

Type of Filling	Details of Damage to Leading Edge	Figure of Merit
A. Laminated C.E./E.D.1.	Rd. No.3 2½ ft. span disrupted. 1½ ft. span inboard top skin torn open and bottom skin ballooned severely, and further 2 ft. span ballooned slightly. 4 ft. span outboard ballooned and dished severely.	120
	Rd. No.15 3 ft. span blown out. 4 ft. span outboard ballooned and dished and nose joint opened.	100
B. Laminated C.E./E.D.1. filled 4/5 capacity.	Rd. No.14 34 in. x 14 in. hole in top skin and 24 in. x 14 in. hole in bottom skin. 4 ft. span outboard ballooned.	55
C. Pressed C.E./S.R.379	Rd. No.2 4 ft. span disrupted. 4 ft. span inboard ballooned slightly. 3½ ft. span outboard ballooned and dished and nose joint opened.	100
	Rd. No.12 3 ft. span blown out. 2 ft. span inboard ballooned slightly. 4 ft. span outboard ballooned and dished and nose joint opened. Further 1 ft. span ballooned slightly.	100
D. Pressed C.E./S.R.379 filled 4/5 capacity.	Rd. No.5 29 in. x 15 in. hole in top skin and 36 in. x 12 in. hole in bottom skin. 4 ft. span outboard ballooned and dished.	60
	Rd. No.13 3 ft. span of top and bottom skin opened out. 4 ft. span outboard ballooned and dished.	60
E. Torpex (Poured)	Rd. No.1 4 ft. span blown out. 4 ft. span inboard ballooned and dished severely. 2½ ft. span outboard disrupted and further 2 ft. span ballooned slightly.	125
	Rd. No.10 4½ ft. span blown out. 4 ft. span inboard ballooned slightly. 2 ft. span outboard top skin torn open and bottom skin ballooned severely, and further 2½ ft. span ballooned slightly.	125
F. R.D.X./T.N.T. (55/45)	Rd. No.4 2 ft span disrupted. 4½ ft. span outboard ballooned and dished.	65
	Rd. No.16 2 ft. span blown out. 1 ft. span outboard disrupted and further 4 ft. span ballooned and dished severely.	80

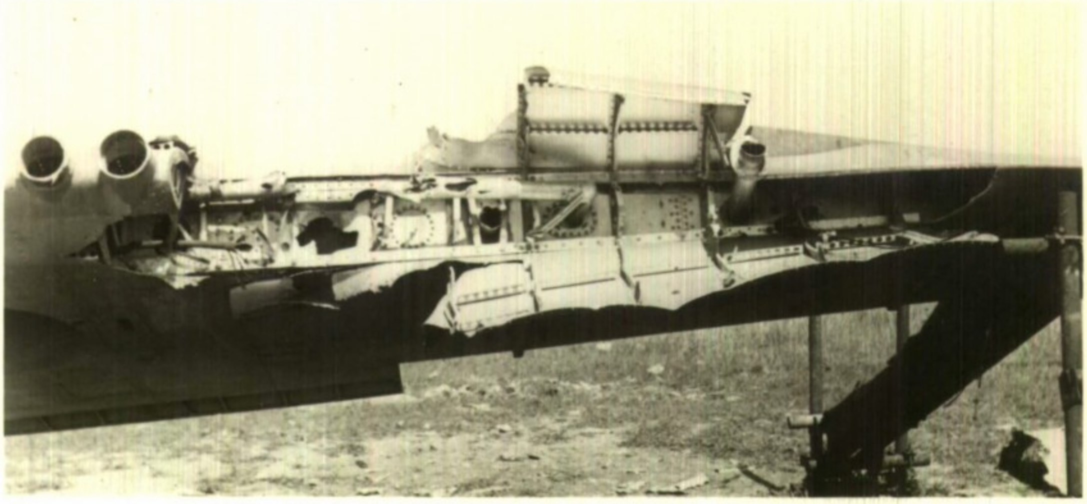
TABLE II (Contd.)

Type of Filling	Details of Damage to Leading Edge	Figure of Merit
G. C.E/Al/SR.379	Rd. No.7 3 ft. span disrupted. 3 ft. span inboard ballooned slightly. 2 ft. span outboard ballooned and dished and nose joint opened, and further 4 ft. span ballooned and dished severely.	100
	Rd. No.17 3 ft. span disrupted. 3 ft. span inboard ballooned and dished. 4 ft. span outboard ballooned and dished and nose joint opened, and further 1 ft. span ballooned slightly.	100
H. R.D.X./Amm. Nitrate/T.N.T/Al	Rd. No.9 3 ft. span blown out. 4 ft. span outboard ballooned and dished severely.	100
	Rd. No.18 3 ft. span blown out. 1 ft span inboard ballooned slightly. 4 ft. span outboard ballooned and dished and nose joint opened.	100
J. C.E/Al/E.D.1.	Rd. No.8 3 ft. span blown out. 3 ft. span outboard ballooned and dished and nose joint opened, and further $1\frac{1}{2}$ ft. span ballooned slightly.	95
K. Torpex (pressed)	Rd. No.6 3 ft. span blown out. 4 ft. span outboard ballooned and dished severely.	90
	Rd. No.11 3 ft. span blown out. 2 ft. span inboard ballooned slightly. 4 ft. span outboard ballooned and dished and nose joint opened.	100

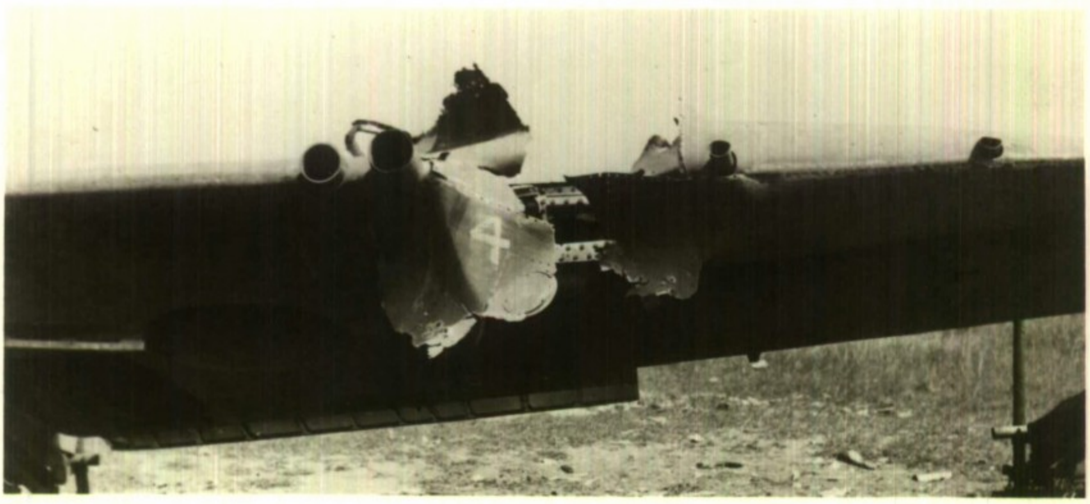
TABLE III

SUMMARY OF RESULTS IN ORDER OF MERIT

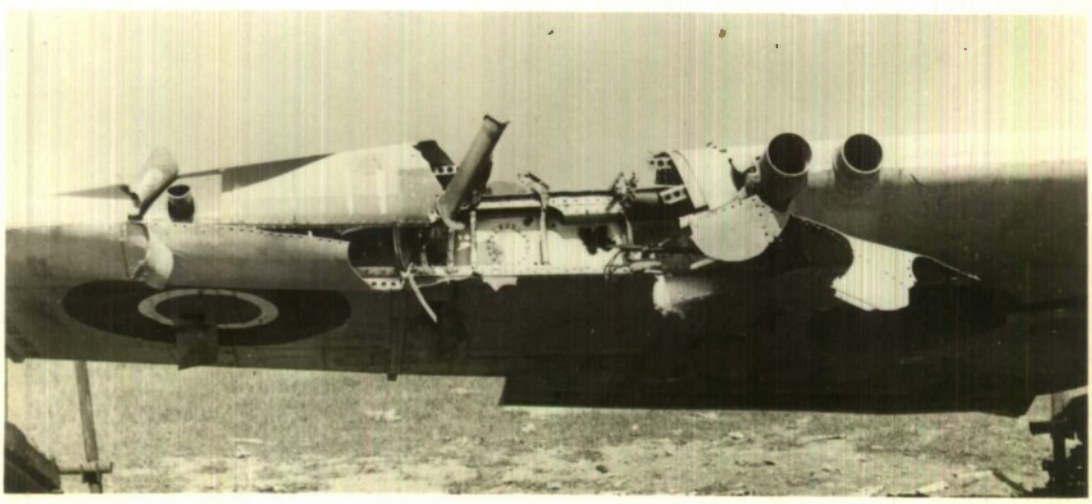
TYPE OF FILLING		FIGURE OF MERIT		
		FIRST FIRING	SECOND FIRING	AVERAGE
E.	Torpex (Poured)	125	125	125
A.	Laminated C.E./E.D.1.	120	100	110
C.	C.E./S.R.379 (British H.E./I.)	100	100	100
G.	C.E./Al./S.R.379	100	100	100
H.	R.D.X./Amm.Nitrate/T.N.T/Al.	100	100	100
J.	C.E./Al./E.D.1.	95	-	95
K.	Torpex (Pressed)	90	100	95
F.	R.D.X./T.N.T.	65	80	72.5
D.	C.E./S.R.379 (80% cavity filled)	60	60	60
B.	C.E./E.D.1. (80% cavity filled)	55	-	55



FILLING E. POURED TORPEX, RDX/TNT/al (40/45/15)
FIGURE OF MERIT:- 125



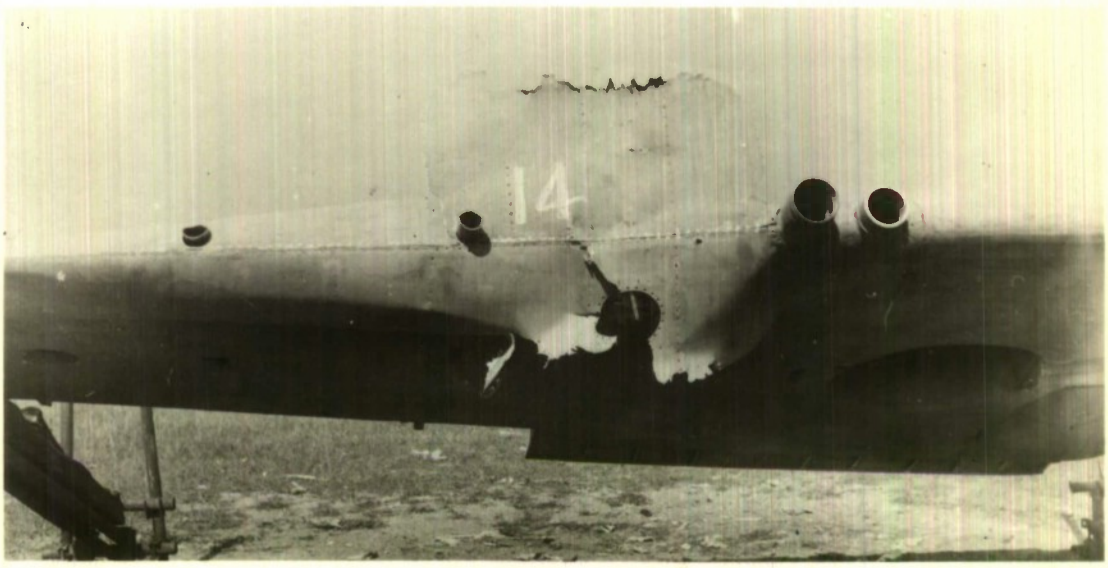
FILLING F. RDX/TNT (55/45)
FIGURE OF MERIT:- 65



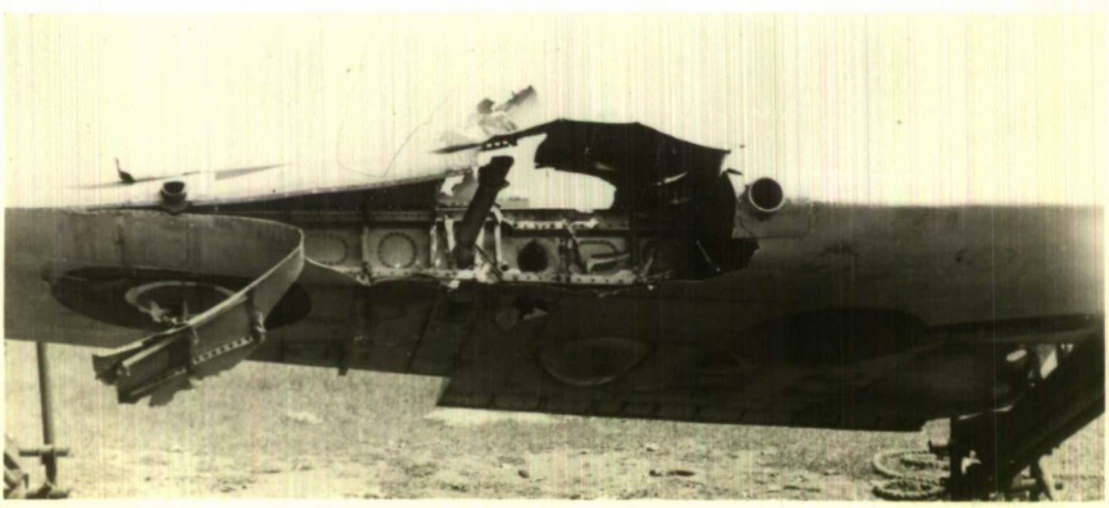
FILLING K. PRESSED TORPEX, RDX/TNT/al (40/45/15)
FIGURE OF MERIT:- 100

FIG.1. EFFECTS OF ADDITION OF ALUMINIUM TO R.D.X./T.N.T. MIXTURES

FILLING A. LAMINATED C.E./E.D.1
FIGURE OF MERIT:- 100



FILLING B. LAMINATED C.E./E.D.1 (4/5 CAPACITY FILLED)
FIGURE OF MERIT:- 55



FILLING C. C.E./S.R.379
FIGURE OF MERIT:- 100

FIG.2. EFFECTS OF H.E./I MIXTURES AND REDUCTION OF EXPLOSIVE WEIGHTS

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Wilts
SP4 0JQ
Tel: 01980-613753
Fax 01980-613970

Defense Technical Information Center (DTIC)
8725 John J. Kingman Road, Suit 0944
Fort Belvoir, VA 22060-6218
U.S.A.

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Record Summary:
Title: Comparison of blast damage effects of HE/1 and HE charges: note on trials at ground level with 2oz fillings detonated statically in aircraft wings
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